SPECTRAL WAVE DECAY DUE TO BOTTOM FRICTION ON THE INNER SHELF

Timothy P. Stanton
Oceanography Department
Naval Postgraduate School
Monterey, CA 93943-5000
phone: (831) 656 3144 fax: (831) 656 2712 email: stanton@oc.nps.navy.mil

Edward B. Thornton
phone: (831) 656 2847 fax: (831) 656 2712 email: thornton@oc.nps.navy.mil

Award#: N0001498WR30010

LONG-TERM GOALS

Long term goals are to observe and model wave and boundary layer processes to determine to wave dissipation in the coastal and nearshore ocean using novel instrumentation techniques.

SCIENTIFIC OBJECTIVES

The primary scientific objective of this project is to measure the bottom dissipation of surface gravity waves as they shoal across the continental shelf. Detailed observations of the bottom boundary layer, resolving the thin oscillatory boundary layer, will be made at several field sites with differing wave forcing, mean currents and sediment bed types to develope a spectral wave dissipation model for the continental shelf. At each site, continuous maps of the small scale morphology will be made surrounding the detailed bottom boundary layer measurements to study changes in the bed in response to wave forcing, and to correctly interpret the effects of these morphology changes on the BBL observations. The spectral dissipation model will include the potentially strong influence of a wave-forced mobile bed, and parameterizations for low frequency currents.

APPROACH

At each of the field deployment sites, dissipation in the bottom boundary layer and wave / current forcing are being measured with a hierarchy of acoustic-based instrumentation including a 0.8 cm-resolution, three component Bistatic Coherent Doppler Velocimeter (BCDV) (Stanton 1996 1998) which measures vertical profiles of velocity and sediment concentration over a 60cm range above the bed at a 20Hz rate. These small-scale measurements of the bottom boundary layer are extended through the water column with *in situ* travel-time current sensors and up to the ocean surface with a high speed Broad Band Acoustic Doppler Profiler. Wave dissipation rates in the mean current and wave-forced bottom boundary layer are being estimated by decomposing mean, wave, and turbulent components of the three component velocity vector profiles to estimate the dissipative components of the fluid motion. The co-located measurements

Report Documentation Page

Form Approved
OMB No. 0704-0188

1. REPORT DATE **1998**	2. REPORT TYPE	3. DATES COVERED **00-00-1998 to 00-00-1998**

4. TITLE AND SUBTITLE **Spectral Wave Decay Due to Bottom Friction on the Inner Shelf**	5a. CONTRACT NUMBER
	5b. GRANT NUMBER
	5c. PROGRAM ELEMENT NUMBER
6. AUTHOR(S)	5d. PROJECT NUMBER
	5e. TASK NUMBER
	5f. WORK UNIT NUMBER
7. PERFORMING ORGANIZATION NAME(S) AND ADDRESS(ES) **Naval Postgraduate School,Department of Oceanography,Monterey,CA,93943**	8. PERFORMING ORGANIZATION REPORT NUMBER
9. SPONSORING/MONITORING AGENCY NAME(S) AND ADDRESS(ES)	10. SPONSOR/MONITOR'S ACRONYM(S)
	11. SPONSOR/MONITOR'S REPORT NUMBER(S)

12. DISTRIBUTION/AVAILABILITY STATEMENT
Approved for public release; distribution unlimited

13. SUPPLEMENTARY NOTES
See also ADM002252.

14. ABSTRACT

15. SUBJECT TERMS

16. SECURITY CLASSIFICATION OF:			17. LIMITATION OF ABSTRACT	18. NUMBER OF PAGES	19a. NAME OF RESPONSIBLE PERSON
a. REPORT **unclassified**	b. ABSTRACT **unclassified**	c. THIS PAGE **unclassified**	**Same as Report (SAR)**	**6**	

Figure 1. The Bistatic Coherent Doppler Velocity profiler (BCDV) on the instrumented sled during SANDYDUCK. The scanning X/Y altimeter has a white head and black transducer on the same vertically moveable frame as the BCDV.

of the velocity vector profiles and sediment concentration allow the sediment buoyancy terms in the TKE balance in the bottom boundary to be estimated when sediment suspension is occurring. As the local sediment morphology can greatly influence the characteristics of the bottom boundary layer (for example Faria *et al* 1997), a two axis scanning sonar altimeter has been developed to quantitatively measure finescale morphology over a 4 by 2m area centered on the BCDV profile measurements with 4cm horizontal and 0.5cm vertical resolutions. These local morphology maps are extended by qualitative 2D side-scan morphology images out to a 20m radius. During the main shoaling waves experiment at Duck NC in 1999, cross-shelf side-scan measurements of the bed will be made to estimate mobile bed changes during storms, and the dissipation model will be tested against *in situ* cross shelf wave observations being made by Tom Herbers and colleagues.

WORK COMPLETED

A prototype versions of the BCDV and scanning altimeter were successfully deployed on an instrumented sled during the SANDYDUCK nearshore experiment at Duck, NC during September and October 1997 (Figure 1). Each day the sled was hauled offshore beyond the sand bar to approximately 4m depth, and moved onshore every hour to occupy measurement points spanning the nearshore region to study a range of sediment transport and wave transformation processes. Approximately half of the offshore measurement sites were representative of inner shelf, shoaling wave conditions, particularly on days with narrow banded, lower energy swell. The prototype scanning sonar provided high resolution local maps of the morphology around the BCDV profiles, while a set of eight acoustic altimeters mounted on the the Army Corps of Engineers CRAB vehicle extended these local maps to an area 1km offshore and 2km alongshore while the CRAB performed large scale surveys of the SANDYDUCK site. The data set has been re-processed to produce continuous timeseries of BCDV profiles at each station, and analysis techniques have been completed to extract dissipation and shear production profiles (Stanton, 1998). Processing improvements have been implemented on the scanning X/Y altimeter which

now allows a selection of scanning modes determined by the tradeoff between sample precision and synoptic coverage of the evolving morphology. Construction was started in the second half of FY98 of the second generation BCDV with .8cm vertical (u,v,w) profiling resolution, which required 4 DSP• s in the instrument head and a significant hardware and coding development. The new BCDV will be field tested in a deployment in Monterey Bay in February 1998, and then deployed in the main DRI experiment from September to December 1999 at Duck, NC.

RESULTS

Analysis of the scanning altimeter and BCDV observations at SANDYDUCK have shown that both instruments performed well, even in the strong wave forcing conditions experienced during storms when the surf zone extended offshore from the inner bar. This experience suggests that the instruments will work well during the two month 12m depth deployment in the main Shoaling Waves DRI experiment at Duck in late 1999.

The prototype BCDV resolved the bottom boundary adequately during the SANDYDUCK measurements, and we have developed techniques for estimating turbulent Reynolds stresses without wave/slope contributions. Profiles of mean velocity components (with u cross-shore and v longshore), scalar horizontal Reynolds stress, u*, and shear production(o symbols) and dissipation rate (+ symbols) are shown for sites on the same day in Figures 2 and 4. The offshore wave height, H_{mo} was 0.5m, and station 3 (Figures 2 and 3) was measured in 1m water depth within the main bar, while station 4 was in 4m depth seaward of the bar. These two stations were selected to contrast the effects of moderate wave breaking, shallow conditions with strongly rippled bed for station 3, in contrast to no wave breaking, deeper, smoother bed offshore at station 4. The inshore station shows nearly two orders of magnitude greater dissipation rates near the bed, enhanced offshore mean velocity at .1m above the bed with a mean onshore flow within the wave boundary layer.The relatively high dissipation rates extending up into the water are due to the downward advection of turbulence from the near-surface breaking, and are not reflected in the local shear production estimates. Figures 3 and 5 show the bottom morphology at these two stations, with the 0.2m amplitude along-shore orientated ripple crests clearly evident at station 3, in contrast to the 1 -2 cm ripples at the offshore site. The large scale ripples directly affect the near-bed mean currents, shear turbulent production and dissipation.

IMPACT / APPLICATIONS

Observations of cross shelf wave shoaling and energy loss under low wind conditions across the continental shelf (for example Hendrickson 1996) suggest that bottom dissipation is a zero• th order term in the cross-shelf wave evolution. Modelling of bottom dissipation in coastal regions will directly improve shelf wave models, which have wide ranging navy and civilian applications.

RELATED PROJECTS

This research has benefited from and contributed to the ONR-sponsored SANDYDUCK program in the development and deployment of the scanning X/Y altimeter and BCDV, which address

overlapping issues in both programs.

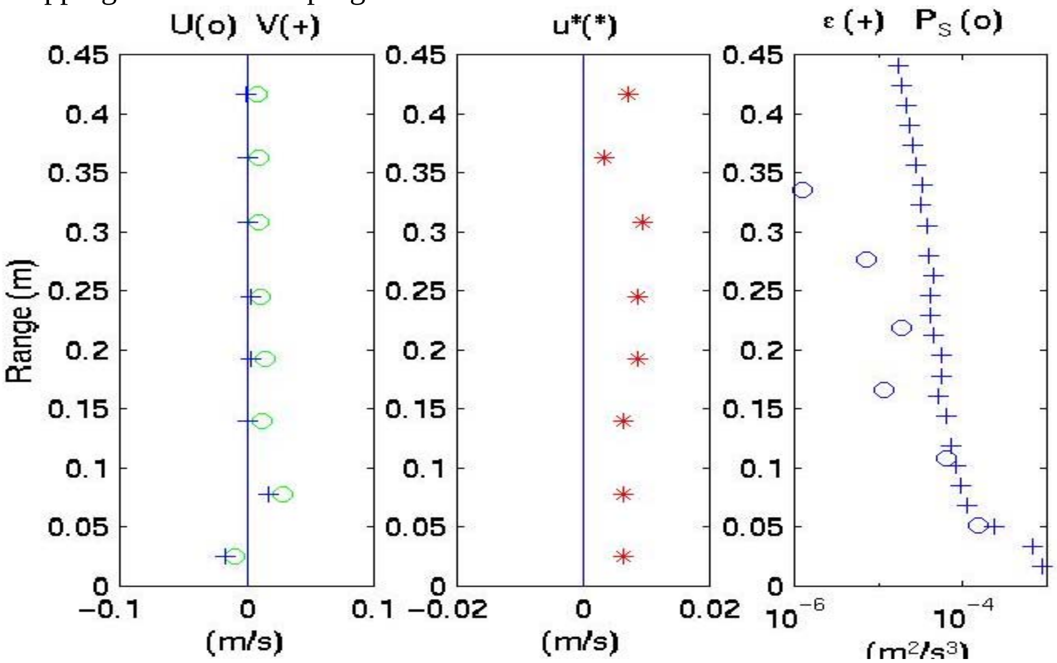

Figure 2. Vertical profiles of cross-shore (o) and longshore (+) mean currents, turbulent friction velocity (*), dissipation (+, right panel) and shear production (o right panel) at a 1m depth site shoreward of the bar at SANDYDUCK

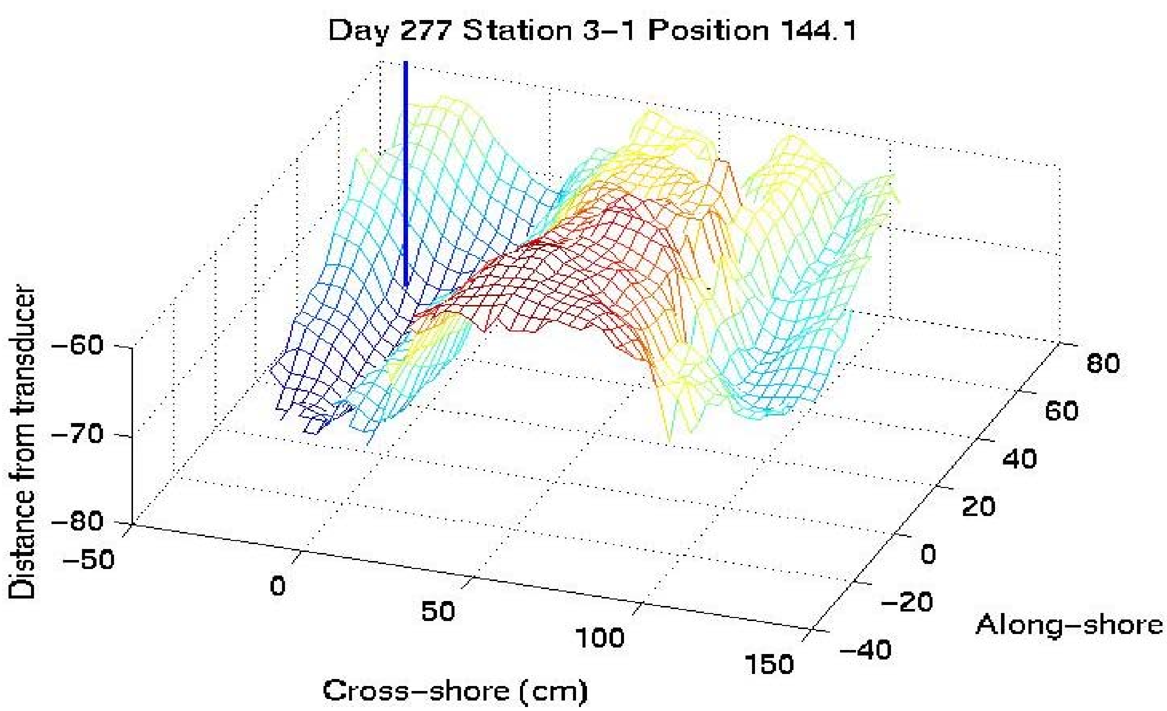

Figure 3. The local morphology measured by a scanning X/Y altimeter during the measurments shown in Figure 2. The location of the vertical acoustic doppler velocity profiles is shown as the vertical line near the cross-shore origin. The large amplitude, 1m scale ripples were typical of the

trough bed.

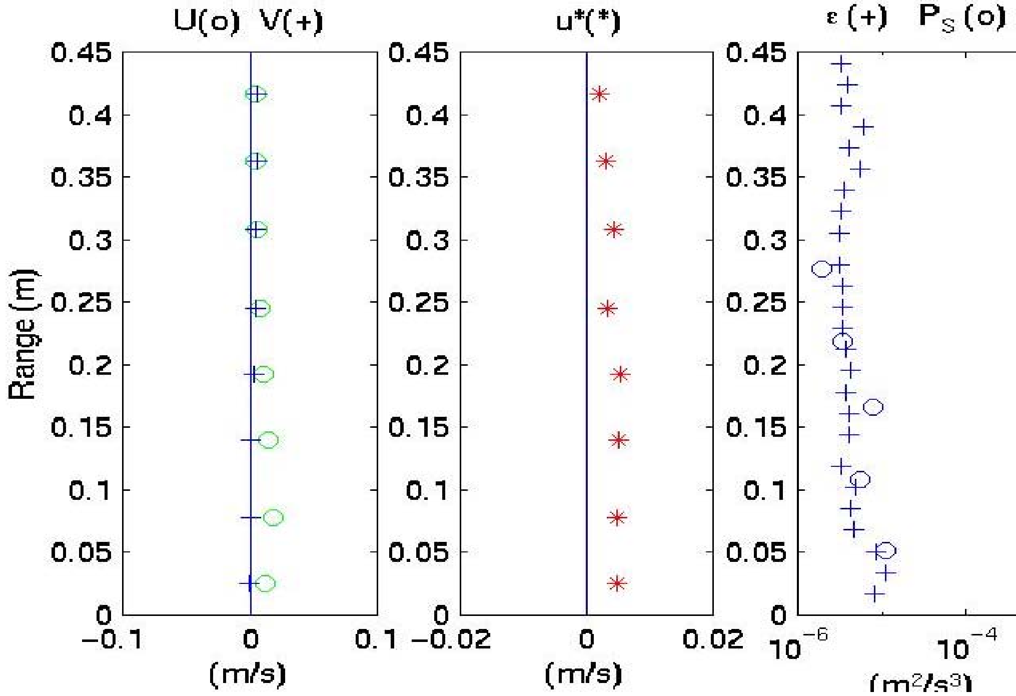

Figure 4. Vertical profiles of cross-shore (o) and longshore (+) mean currents, turbulent friction velocity (*), dissipation (+, right panel) and shear production (o right panel) at a 4m depth site seaward of the bar at SANDYDUCK

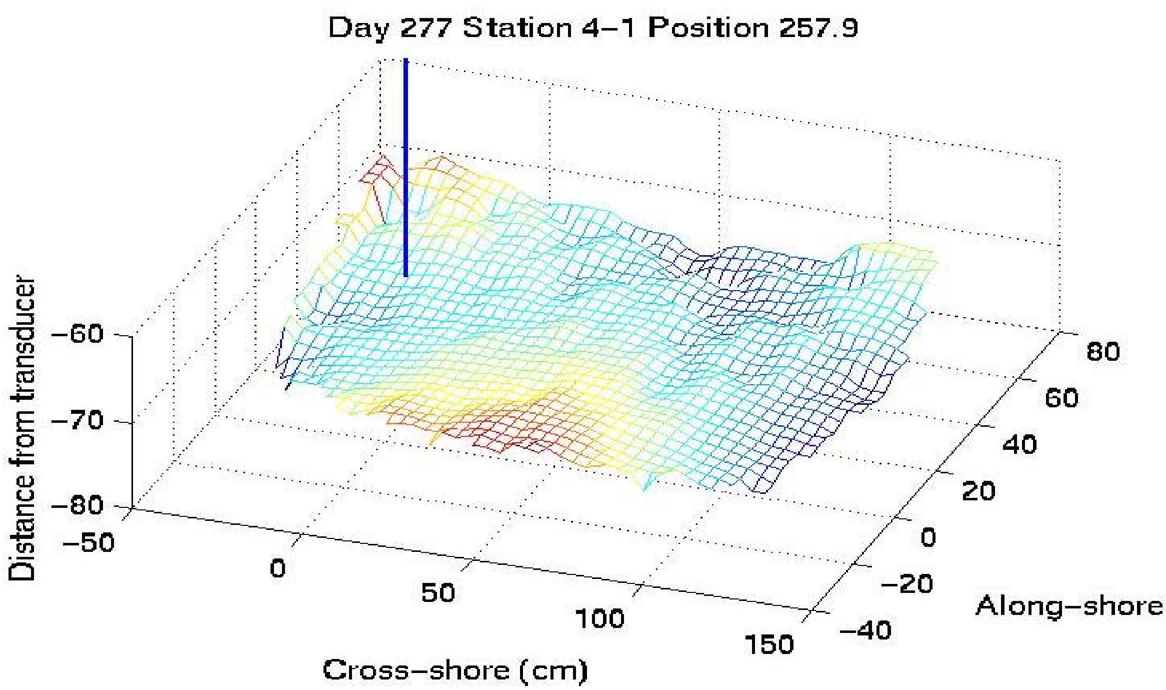

Figure 5. The local morphology measured by a scanning X/Y altimeter during the measurments shown in Figure 4. The location of the vertical acoustic doppler velocity profiles is shown as the vertical line near the cross-shore origin. The bed at this offshore location had low amplitude

small scale ripples with ~1.5cm RMS amplitude.

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